FORMA05 - Practical works of the formation “advanced Use”: Plate fissured in traction

Summary:

This test $2D$ deformation plane, into quasi-static, enters within the framework of the validation of postprocessings in linear elastic breaking process. The fissured plate is put in traction.

1 Problem of reference

1.1 Geometry

One considers a rectangular plate height $H=2\,m$, of width $W=1\,m$, in plane deformation, with an emerging horizontal crack of depth $a=0,1\,m$.

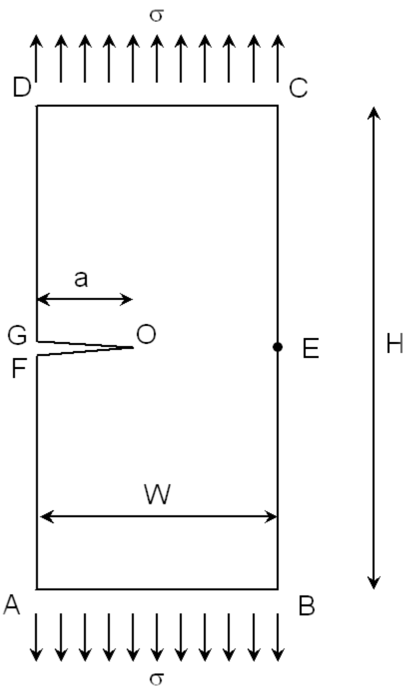

Figure 1.1-1: diagram of the fissured plate

1.2 Material properties

One considers a linear elastic isotropic material homogeneous whose characteristics are the following ones:

- Young modulus $E=210\ 000\,MPa$
- Coefficient of Fish $\nu=0,3$

1.3 Boundary conditions and loadings

The plate is in traction ($\sigma=10\,MPa$).

2 Reference solution

2.1 Method used for the reference solution

The reference solution [1] is expressed in the following way:

$$K_I=\sigma\sqrt{\pi a}\,F\left(\frac{a}{W}\right)$$

with $F\left(\frac{a}{W}\right)=1{,}122-0{,}231\left(\frac{a}{W}\right)+10{,}55\left(\frac{a}{W}\right)^2-21{,}71\left(\frac{a}{W}\right)^3+30{,}382\left(\frac{a}{W}\right)^4$

The precision of this empirical formula is of $0{,}5$ for $\frac{a}{W}\leq 0{,}6$.

One can also calculate G thanks to the formula of Irwin:

$$G(s)=\frac{\left(1-\nu^2\right)}{E}K_I^2$$

2.2 Results of reference

With the digital values of the statement, one finds: $K_I=6{,}65\,MPa.\sqrt{m}$ and $G=192\,J.m^{-2}$.

2.3 Bibliographical references

• H. Tada, P. Paris, G. Irwin, The stress analysis of aces handbook, 3 rd edition, 2000

3 Modeling a: FEM 2d

3.1 Unfolding of the TP

3.1.1 Geometry and grid with Salomé-Meca

By taking of account the symmetry of the geometry defined on Figure 1, only the higher half of the model will be represented. This geometry can be built with Geometry module of Salomé-Meca by using the functionality `New Enity/BASIC/`*`2D Sketch`* then *`Build/Face`*. One will take care to define the geometrical groups O , E , CD , GO and OE on the face thus created by using the functionality `New Enity/Explode`.

With the module Mesh de Salome-Meca, by using Netgen 1D-2D: to choose *`NETGEN 2D Parameters`* then *`Max. Size`* = $0{,}1\,m$, *`Min. Size`* = $0{,}005\,m$, option *`Fine Very`* and coachman the box *`Second Order`* to obtain a quadratic grid directly. This algorithm also makes it possible to define a size of the meshs locally (mitre *`Room sizes`*). One will be able for example to specify elements of $0{,}005\,m$ near the bottom of crack. Do not forget by importing the groups of meshs and nodes according to the geometrical groups O , E , CD , GO and OE .

3.1.2 Calculation of the field of displacement

Besides the force of traction imposed on the segment CD (to be imposed with `FORCE_CONTOUR`), it is necessary to take into account the condition of symmetry, by blocking following displacement Y segment OE .

To prevent the movements of rigid body, one will block the side displacement of the node E (or O). To visualize the fields of displacement and constraints obtained.

(to save time, you can make use of the file `forma05a.comm`)

3.1.3 Calculation of K and G

To define the bottom of crack in `DEFI_FOND_FISS` starting from the groups of meshs of the bottom and lips. The model being symmetrical, it is necessary to specify SYME=' OUI'.
To calculate the factors of intensity of the constraints and the rate of refund of energy with `POST_K1_K2_K3` and `CALC_G` (the keyword DIRECTION under THETA will have to be indicated in order to indicate the direction of the field theta in CALC_G). Parameters of the operators (`R_INF`, `R_SUP`, `ABSC_CURV_MAXI`…) will be to define according to the grid used.

One is reminded that the orders `POST_K1_K2_K3` and `CALC_G` produce structureS data of the type Counts. IL is necessary to add the order `IMPR_TABLE` to display the computation results.

To compare the solution obtained with the reference solution.

To put elements of Barsoum in bottom of crack (operator `MODI_MAILLAGE/MODI_MAILLE/NOEUD_QUART`) and to look at how the result is modified.

3.1.4 Studies of influence

- On `CALC_G` : to check the independence of the result to the choice of the crowns of integration of the field theta;
- On `POST_K1_K2_K3` : to study the influence of the parameter `ABSC_CURV_MAXI` ;
- ON can also modify the refinement of the grid (*`Room sizes`* with NETGEN 1D-2D).

3.2 Sizes tested and results

3.2.1 Tests on G

Identification	Reference	% tolerance
G of CALC_G, option CALC_G	192	0,3%
G of CALC_G, option CALC_K_G	192	0,3%
G_{Irwin} of CALC_G, option CALC_K_G	192	0,3%
G of POST_K1_K2_K	192	0,6%

3.2.2 Tests on KI

Identification	Reference	% tolerance
K_I of CALC_G, option CALC_K_G	$6.65\ 10^6$	0,3%
K_I of POST_K1_K2_K	$6.65\ 10^6$	0,4%

4 Synthesis

This TP makes it possible to highlight:

- Interest of a quadratic grid compared to a linear grid;
- The invariance of the results to the choices of the crowns;
- Improvement of the precision of the results resulting from POST_K1_K2_K thanks to the use of elements of Barsoum.